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Correlation and Path Coefficient Analysis for Yield and Its Component Traits in Advanced Breeding Lines of Rice (*Oryza sativa* L.)

Pattapu Jahnavi Mahalakshmi [a*], Y. Satish [b], J. V. Ramana [b] and M. RB. Raju [c]

[a] Acharya N.G. Ranga Agricultural University, Bapatla-522101, India.
[b] Acharya N.G. Ranga Agricultural University, Lam, Guntur-522034, India.
[c] Agricultural Research Station, Peddapuram-533437, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To evaluate correlation and path analysis for nine yield attributing traits across sixty advanced breeding lines.
Study Design: The experiment was laid out in Alpha lattice design in 2 replications.
Place and Duration of Study: This study was conducted at the Regional Agricultural Research Station in Maruteru during kharif, 2023
Methodology: Sixty advanced breeding lines of rice were evaluated for nine yield and its attributing traits. Correlation analysis, direct and indirect effects on grain yield per plant through path

**Corresponding author: E-mail: jmlpattapu23@gmail.com;*

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coefficient analysis were calculated. The traits examined included days to 50% flowering, days to maturity, plant height, panicle length, ear-bearing tillers per square meter, spikelet fertility, grains per panicle, test weight and grain yield per plant.

Results: Correlation analysis revealed that plant height, ear-bearing tillers per square meter, panicle length, and grains per panicle exhibited significant positive correlations with grain yield per plant. This underscores the importance of these traits in contributing to improved yield outcomes. Path analysis results indicated that days to 50% flowering, ear-bearing tillers per square meter, panicle length, grains per panicle and test weight showed direct positive associations with grain yield per plant.

Conclusion: These findings highlight the significance of these specific traits as key selection indicators in breeding programs aimed at enhancing yield. Overall, emphasizing these traits in breeding efforts is shown to lead to improvements in grain yield per plant, making them crucial targets for selection and improvement strategies in rice breeding programs.

Keywords: Correlation; path analysis; advanced breeding lines; rice; selection indicator.

1. INTRODUCTION

Rice [*Oryza sativa* L.] holds an essential place in Indian agriculture as it can thrive in a range of ecological conditions. India ranks second in global rice production that accounts for 26% of total rice production. Total production in India is 137 million metric tons during the year 2023/2024. In the year 2023/2024 worldwide production of rice accounts for 520.87 million metric tons [1]. Rice cultivars with better yields are desperately needed to meet future consumer demands. However, the net impact of yield component characteristics determines yield primarily.

Correlation is a statistical measure used to understand the relationships between different traits, which can be valuable for improving yield through selection. Genotypic correlation assesses how genetic components influencing various traits are related, while phenotypic correlation considers the combined effects of both genetic and environmental factors. Path analysis, on the other hand, evaluates how individual yield component traits contribute to overall grain yield, accounting for both direct and indirect effects.

2. MATERIALS AND METHODS

2.1 Study Location

This study was conducted during the *kharif,* 2023 at the Regional Agricultural Research Station in Maruteru, West Godavari district, Andhra Pradesh. The station is located at a longitude of 81.44^0, a latitude of 26.38^0 N, and an elevation of 5 meters above sea level, within the Godavari Zone of Acharya N. G. Ranga Agricultural University. The research involved sixty advanced breeding lines, including the check varieties MTU-1121, TN-1 and RP Bio-226. Among the sixty advanced breeding lines, 21 lines were Nellore (NLR) varieties with a cross combination of RPBIO226/NLR34449, five IRRI lines and the remaining lines with different combinations of Maruteru (MTU) varieties. The evaluation of these lines was carried out using an alpha lattice design with two replications, focusing on nine metric traits *viz*., days to 50% flowering, days to maturity, plant height, panicle length, ear-bearing tillers per square meter, spikelet fertility, grains per panicle, test weight and grain yield per plant. All the 60 advanced breeding lines including checks were randomized in 10 blocks with block size of six *i.e.,* each block consists of six lines.

2.2 Statistical Analysis

The mean values over replications were computed for traits mentioned in this study. These values were subjected to correlation analysis by using formulas proposed by Falconer to compute genotypic and phenotypic correlations [2]. The calculated values were compared to the correlation coefficient table values in order to evaluate the significance of the correlation coefficient as specified by [3]. In path analysis, direct and indirect effects were calculated as per Dewey and Lu [4]. Statistical Analysis is being carried out by using INDOSTAT software.

3. RESULTS AND DISCUSSION

3.1 Correlation Studies

The genotypic and phenotypic correlation for eight metric traits with yield is mentioned in Table 1. Genotypic and phenotypic correlation matrix were depicted in Figs. 1 and 2 respectively.

Table 1. Correlation among yield and studied yield components in rice genotypes

Character		DFF	DM	PH	EBT	PL	GP	SF	TW	GY/P
DFF	r_g	1	0.956**	0.515**	0.011	0.219*	0.352**	-0.0219	0.1438	0.1438
	r_p	1	0.956**	0.515**	0.0145	0.221*	0.354**	-0.262*	-0.0229	0.1414
DM	r_g		1	0.483**	0.0178	0.227*	0.341**	-0.221*	-0.0009	0.0923
	r_p		1	0.484**	0.0181	0.227*	0.342**	-0.221*	-0.0009	0.0931
PH	r_g			1	0.1107	0.448**	0.435**	-0.215*	0.1405	0.256*
	r_p			1	0.1221	0.456**	0.442**	-0.214*	0.1383	0.248*
EBT	r_g				1	-0.0184	0.0608	-0.0142	-0.1145	0.246*
	r_p				1	-0.0257	0.0544	-0.0172	-0.1114	0.269*
PL	r_g					1	0.342**	-0.1196	0.243*	0.315**
	r_p					1	0.340**	-0.1212	0.246*	0.328**
GP	r_g						1	0.216*	-0.405**	0.411**
	r_p						1	0.215*	-0.404**	0.425**
SF	r_g							1	-0.1542	0.0263
	r_p							1	-0.1536	0.0302
TW	r_g								1	-0.0375
	r_p								1	-0.0429
GY/P	r_g									1
	r_p									1

*** Significant at 1%, * Significant at 5%*

DFF-Days to 50% flowering, DM-Days to maturity, PH- Plant height, EBT- Ear bearing tillers per m^2, PL- Panicle length, GP- Number of grains per panicle, SF- Spikelet fertility, TW- Test weight, GY/P- Grain yield per plant

Days to 50% flowering exhibited significant positive genotypic correlation with days to maturity (0.956**), plant height (0.515**), panicle length (0.219*) and grains per panicle (0.352**). Significant positive phenotypic correlation is observed with days to maturity (0.956**), plant height (0.515**), panicle length (0.221*) and grains per panicle (0.354). Spikelet fertility (-0.262*) showed significant negative phenotypic correlation with days to 50% flowering. These results were in accordance with Kumar et al. [5], Madishetty et al. [6] for days to maturity; Panika et al. [7] for panicle length; Gupta et al. [8] for spikelet fertility; Parimala et al. [9] for plant height; Such results indicate that increase in duration of crop provides scope for increase in number of grains per panicle, which is in accordance with Madishetty et al. [6] and Parimala et al. [9].

Days to maturity showed significant positive genotypic correlation with plant height (0.483**), panicle length (0.227*) and grains per panicle (0.341**). Similarly, plant height (0.484**), panicle length (0.227*) and grains per panicle (0.342**) showed significant positive phenotypic correlation with days to maturity. Significant negative phenotypic and genotypic correlation was observed for days to maturity with spikelet fertility (-0.221*). Similar findings were recorded by Madishetty et al [6] for grains per panicle; Saha et al. [10] for plant height; Aditya and Bhartiya [11] for panicle length, Gupta et al. [8] for spikelet fertility.

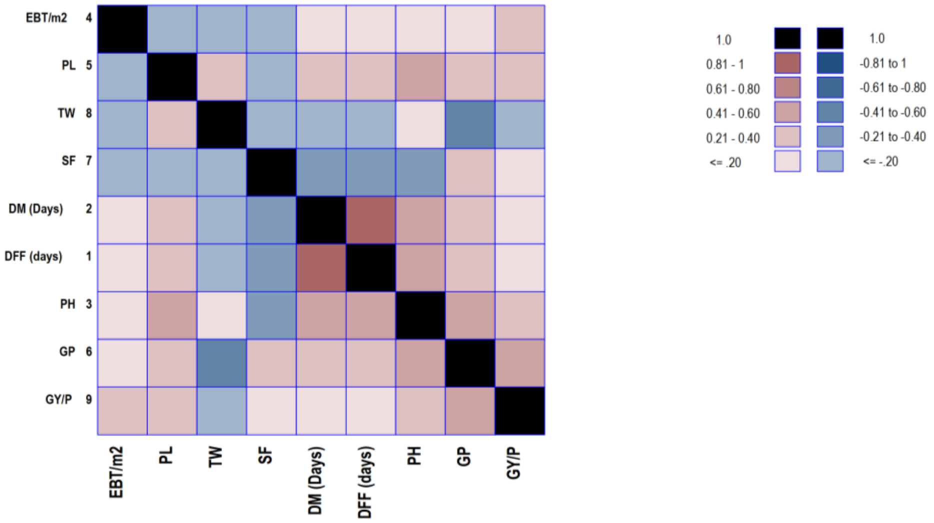

Fig. 1. Genotypic Correlation matrix for yield and yield component traits

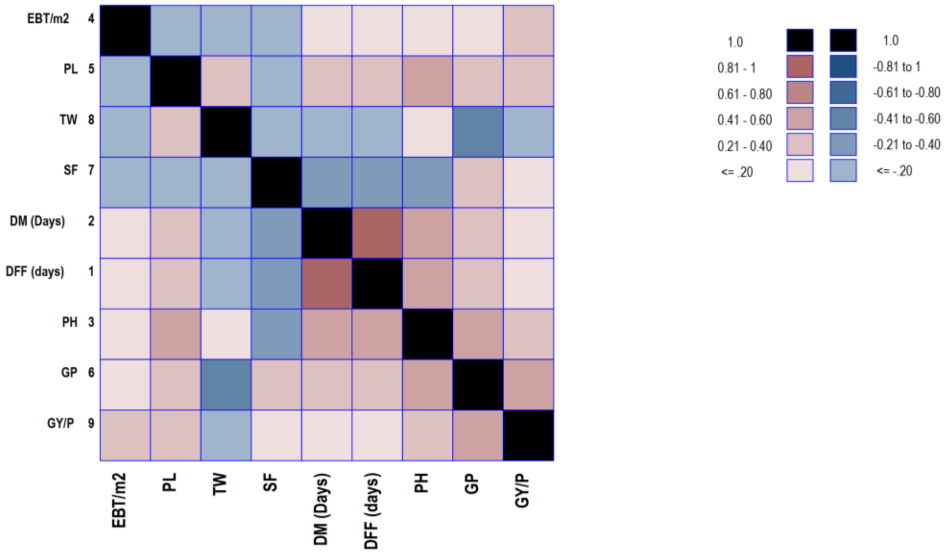

Fig. 2. Phenotypic Correlation matrix for yield and yield component traits

Plant height revealed significant positive correlation with panicle length (0.448**), grains per panicle (0.435**) and grain yield per plant (0.256*). Similarly, significant positive phenotypic correlation was observed with panicle length (0.456**), grains per panicle (0.452**) and grain yield per plant (0.248*). Plant height showed significant negative phenotypic (-0.214*) and genotypic (-0.215*) correlation with spikelet fertility.

These results were in accordance with Parimala et al. [9] for panicle length and grains per panicle. These results indicate that increase in plant height will yield longer panicles with more grains per panicle and higher yields per plant, this was in conformity with the findings of Madishetty et al. [6]. On the other hand, increase in plant height results in lower spikelet fertility, this is in accordance with Panika et al. [7].

Ear bearing tillers per m^2 recorded significant positive genotypic (0.269*) and phenotypic (0.246*) correlation with grain yield per plant. This implies that increase in number of ear bearing tillers leads to significant increase in grain yield. This was in conformity with the findings of Dinkar et al. [12].

Significant positive genotypic correlation was observed for panicle length with grains per panicle (0.342**), test weight (0.243*) and grain yield per plant (0.315**). Similarly, significant positive phenotypic correlation was observed with grains per panicle (0.340**), test weight (0.246*) and grain yield per plant (0.328**). These results indicate that increase in panicle length leads to more number of grains per panicle and bolder grains and increase in single plant yield. These findings were in accordance with the earlier reports of Madishetty et al. [6], Parimala et al. [9] for grain yield; Dinkar et al. [12] for grains per panicle and test weight. Grains per panicle recorded significant positive genotypic correlation with spikelet fertility (0.216*) and grain yield per plant (0.411**). Similarly, significant positive phenotypic correlation was recorded with spikelet fertility (0.215*) and grain yield per plant (0.425**). Significant negative genotypic (-0.405**) and phenotypic (-0.404**) correlation was recorded for grains per panicle with test weight [13].

This result shows that with increase in grains per panicle, the number of filled grains will be more compared to unfilled grains, as a result the spikelet fertility increases that leads to more grain yield per plant. These findings were in accordance with the results of Madishetty et al. [6] for grain yield per plant; Kavya et al. [14] for spikelet fertility and grain yield per plant. With the increase in grains per panicle, the test weight has significantly reduced, this is in accordance with the findings of Krishna et al. [15].

Spikelet fertility showed non-significant positive genotypic (0.0263) and phenotypic (0.0302) correlation with grain yield per plant. Whereas, non-significant negative genotypic (-0.1542) and phenotypic (-0.1536) correlation was recorded with test weight. These results were in accordance with the findings of Kavya et al. [14] for grain yield per plant. Spikelet fertility recorded non-significant negative genotypic (-0.0375) and phenotypic (-0.0429) with grain yield per plant. These results were in concordance with the reports of Krishna et al. (2022). Grain yield per plant recorded significant positive genotypic correlation with plant height (0.256*), ear bearing tillers per m^2 (0.246*), panicle length (0.315**) and grains per panicle (0.411**). Similarly, significant positive phenotypic correlation with plant height (0.248*), ear bearing tillers per m^2 (0.269*), panicle length (0.328**) and grains per panicle (0.425**). Indirect selection for plant height, ear bearing tillers per m^2, panicle length and grains per panicle will lead to significant increase in yield. These results were in accordance with the findings of Madishetty et al. [6] for plant height and panicle length; Dinkar et al. [12] for panicle length and ear bearing tillers per m^2; Kavya et al. [14] for ear bearing tillers per m^2 and grains per panicle.

3.2 Path Analysis

Path analysis is used to ascertain the extent of contribution by several yield attributing variables to the grain yield, comprising of both direct and indirect effects. Correlation coefficients are separated into values of direct and indirect effects. The direct and indirect values for phenotypic and genotypic path analysis were mentioned in Tables 2, 3 respectively and the genotypic and phenotypic path diagrams were depicted in Figs. 3 and 4 respectively.

The direct effect of grains per panicle on grain yield per plant was high, positive at both genotypic (0.431) and phenotypic (0.4603) levels. Direct selection for this trait will be more rewarding as the direct effects are high and positive. Similar results were observed by Abbas [16] "at both genotypic and phenotypic levels. At

Table 2. Phenotypic direct and indirect effects of 8 studied traits on grain yield in rice genotypes

Character	DFF	DM	PH	EBT/ m^2	PL	GP	SF	TW	GY/P
DFF	**0.5442**	-0.5662	-0.0515	0.0041	0.0041	0.163	0.0071	-0.0033	0.1414
DM	0.5202	**-0.5923**	-0.0484	0.0051	0.0454	0.1573	0.006	-0.0001	0.0931
PH	0.2801	-0.2867	**-0.1001**	0.0342	0.091	0.2032	0.0058	0.0203	0.248*
EBT/m^2	0.0079	-0.0107	-0.0122	**0.2801**	-0.0051	0.025	0.0005	-0.0163	0.269*
PL	0.1202	-0.1346	-0.0456	-0.0072	**0.1997**	0.1565	0.0033	0.036	0.328**
GP	0.1928	-0.2025	-0.0442	0.0152	0.0679	**0.4603**	-0.0058	-0.0591	0.425**
SF	-0.1426	0.1311	0.0214	-0.0048	-0.0242	0.0989	**-0.0271**	-0.1465	0.0302
TW	-0.0124	0.0005	-0.0138	-0.0312	0.049	-0.1857	0.0042	**0.1465**	-0.0429

Residual effect: 0.221

Table 3. Genotypic direct and indirect effects of 8 studied traits on grain yield in rice genotypes

Character	DFF	DM	PH	EBT/ m^2	PL	GP	SF	TW	GY/P
DFF	**0.5822**	-0.6047	-0.0291	0.0028	0.0389	0.1517	0.0052	-0.0031	0.1438
DM	0.5563	**-0.6328**	-0.0273	0.0044	0.0403	0.1471	0.0044	-0.0001	0.0923
PH	0.2998	-0.3053	**-0.0566**	0.0276	0.0797	0.1874	0.0042	0.0196	0.256*
EBT/m^2	0.0064	-0.0112	-0.0063	**0.2495**	-0.0033	0.0262	0.0003	-0.016	0.246*
PL	0.1275	-01435	-0.0254	-0.0046	**0.1777**	0.1475	0.0024	0.0339	0.315**
GP	0.205	-0.2159	-0.0246	0.0152	0.0608	**0.431**	-0.0043	-0.0564	0.411**
SF	-0.1528	0.1401	0.0121	-0.0035	-0.0213	0.093	**-0.0197**	-0.0215	0.0263
TW	-0.0128	0.0006	-0.0079	-0.0286	0.0432	-0.1743	0.003	**0.1394**	-0.0375

Residual effect: 0.237

**Direct effects on main diagonal. DFF-Days to 50% flowering, DM-Days to Maturity, PH- Plant height, EBT- Ear bearing tillers per m^2, PL- Panicle length, GP-Number of grains per panicle, SF- Spikelet fertility, TW- Test weight, GY/P- Grain yield per plant.*

both phenotypic and genotypic levels, grains per panicle showed positive indirect effect on grain yield per plant *via* days to 50% flowering, panicle length and ear bearing tillers per m^2. Apart from this positive indirect effect, this trait also showed negative indirect effect on grain yield per plant *via* spikelet fertility, days to maturity, plant height and test weight”.

The direct effect of ear bearing tillers per m^2 on grain yield per plant was moderate and positive at both phenotypic (0.2801) and genotypic (0.2495) levels. This results were in conformity with the findings of Kavya et al. [14]. “Ear bearing tillers per m^2 showed positive indirect effect on grain yield per plant *via* days to 50% flowering, spikelet fertility and grains per panicle at both genotypic and phenotypic levels. Apart from this, this trait showed negative indirect effect on grain yield per plant *via* days to maturity, plant height, panicle length and test weight”.

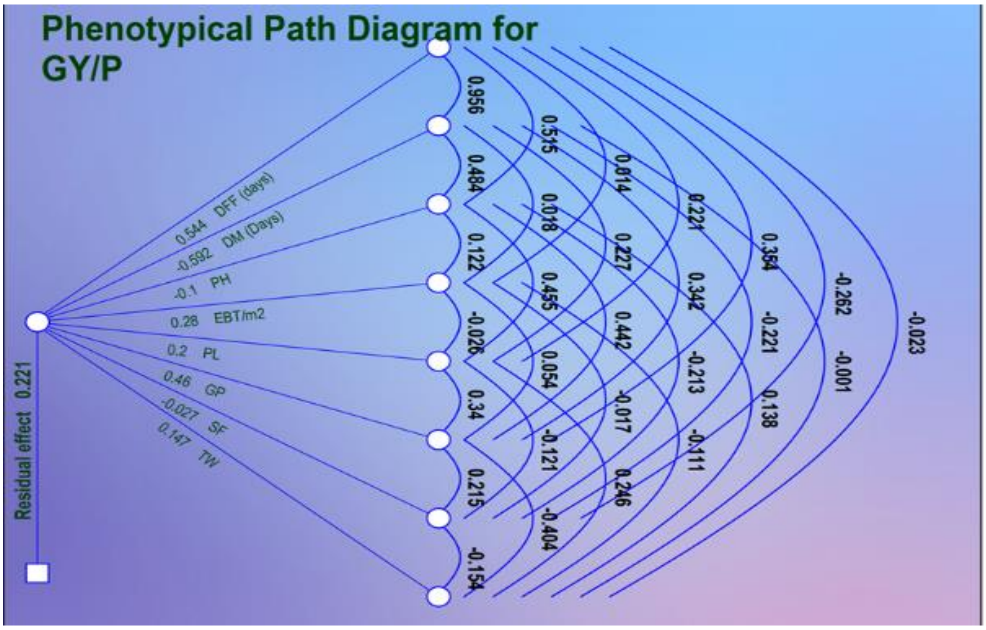

Fig. 3. Phentypic path diagram for yield and its contributing traits

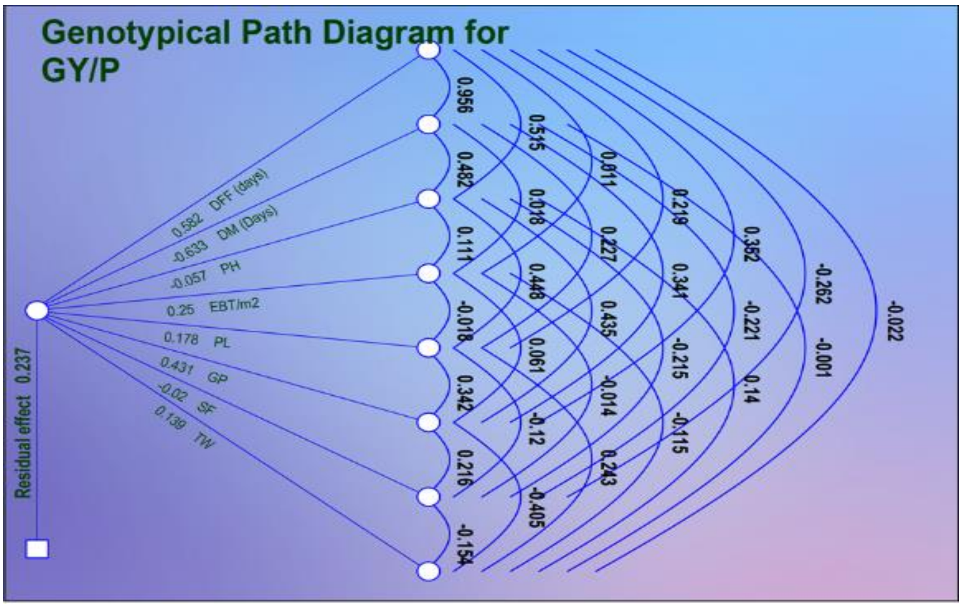

Fig. 4. Genotypic path diagram for yield and its contributing traits

The direct effect of days to 50% flowering on grain yield was observed to be positive and high at genotypic (0.5822) and phenotypic (0.5442) levels. Direct selection for this trait was rewarding upto a certain extent as the direct effects were high at both genotypic and phenotypic levels. This is in accordance with the findings of Panika et al. [7] for both genotypic and phenotypic levels. At genotypic level, days to 50% flowering showed positive indirect effect on grain yield per plant *via* ear bearing tillers per m^2, panicle length, spikelet fertility and grains per panicle. In addition to this positive indirect effect, days to 50% flowering also showed negative indirect effect on grain yield per plant *via* days to maturity, plant height and test weight.

The direct effect of test weight on grain yield per plant was low and positive at both genotypic (0.1394) and phenotypic (0.1465) levels. Similar results were recorded by Abbas [16] at "both genotypic and phenotypic levels. At both genotypic and phenotypic levels, test weight showed positive indirect effect on grain yield per plant *via* days to maturity, spikelet fertility and panicle length. Besides this, test weight showed negative indirect effect on grain yield per plant *via* days to 50% flowering, ear bearing tillers per m^2, plant height and grains per panicle".

"The direct effect of panicle length on grain yield per plant was low, positive at both phenotypic (0.1997) and genotypic (0.1777) levels. Direct selection for this trait for improving grain yield per plant is effective. This was in accordance with the results" of Kavya et al. [14], Parimala et al. [9]. At both phenotypic and genotypic levels, panicle length showed positive indirect effect on grain yield per plant *via* days to 50% flowering, spikelet fertility, grains per panicle and test weight. Apart from this, panicle length showed negative indirect effect on grain yield per plant *via* ear bearing tillers per m^2, plant height and days to maturity.

Highest positive direct effect on grain yield per plant at genotypic level was observed with days to 50% flowering (0.5822) followed by grains per panicle (0.431), ear bearing tillers per m^2 (0.2495), panicle length (0.1777) and test weight (0.1394). Highest positive direct effect on grain yield per plant at phenotypic level was observed with days to 50% flowering (0.5422) followed by grains per panicle (0.4603), ear bearing tillers per m^2 (0.2801), panicle length (0.1997) and test weight (0.1465). Direct selection of these traits, helps in improving grain yield per plant.

Highest negative direct on grain yield per plant at genotypic level was observed with days to maturity (-0.6328) followed by plant height (-0.0566) and spikelet fertility (-0.0197). Highest negative direct on grain yield per plant at phenotypic level was also observed with days to maturity (-0.5923) followed by plant height (-0.1001) and spikelet fertility (-0.0271).

3.3 Residual Effect

The degree to which the causal variables account for the dependent factor's variability is determined by the residual effect. In the present study residual effect was 0.237 and 0.221 at genotypic and phenotypic level respectively. This indicated that 76.3% (genotypic) and 77.9% (phenotypic) variability was exploited by the variables mentioned in this study. In addition to the mentioned factors, some other factors which have not been considered here need to be included in the analysis to account for the complete variation in yield.

4. CONCLUSION

This study has shown that grain yield is positively correlated with traits such as plant height, ear-bearing tillers per square meter, panicle length, and grains per panicle. To enhance selection effectiveness in breeding programs, it is crucial to focus on these traits. Path analysis further reveals that ear-bearing tillers per square meter, grains per panicle, days to 50% flowering, panicle length, and test weight have a positive direct impact on grain yield. This underscores the importance of these traits as key indicators for improving yield.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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